# Internet of Things (IoT) in Academic Libraries

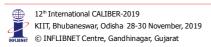*Sheeja N K*                    *Susan Mathew K*

**Abstract**

*This paper reviews the literature on the application of Internet of Things (IoT) in libraries and identifies the prospective areas where IoT can be executed effectively. The literatures on IoT applications retrievable by Google Scholar search during 2010 to 2019 were selected. The number of articles available on this area found to be very less. The authors attempted to provide a comprehensive review on the available articles to generate inferences important to the field of library and information science.*

**Keywords:**    Internet of Things(IoT), IoT applications, Innovative Services, Smart Library

## 1. Introduction

Internet of things (IoT) is a new revolution of the Internet that is rapidly gathering momentum driven by the advancements in sensor networks, mobile devices, wireless communications, networking and cloud technologies (Bahga & Madisetti, 2014). They are interrelated networks that allow devices to receive and send data with each other via Internet. IoT is defined as "a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual 'Things' have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network" (Kranenburg, 2008).

The term IoT was first coined by Kevin Ashton in 1999. Firstly, the term was introduced to describe how IoT was created by adding RFID and other sensors to everyday objects (Simões, Filipe & Barbosa, 2019). In IoT the things function like smart

and living entities by sensing and communicating through embedded devices which interact with sensors. IoT consists of the networks of physical objects, the traditional network of the Internet, and various devices (gateway, border router etc.) that connect these networks (Tkachenko & Brezhniev, 2019). Xu *et al.* (2014) stated that RFID and WSN are the foundational technologies of IoT and service-oriented architecture as a key technology in integrating heterogeneous systems or devices that can be applied to support IoT. The identification and tracking technologies, communication technologies, networking technologies and service management form the four-layer architecture of IoT (Liang, 2019).

The application of IoT extends to a wide range of domains including homes, cities, environment, energy systems, retail, logistics, industry, agriculture, health etc. This paper is concentrating on the application of IoT in libraries. It is an area that can make drastic changes in services as well as management of libraries. The application of IoT in libraries saves time of the patron and provides a digital view of physical items for finding location of

things (Gupta and Singh, 2018) and it improves workflow and service, integrate existing resource and system to achieve service innovation, connect library resources and services to more people than before (OCLC, 2015). This paper reviews the available literature on this topic related to libraries and information centres.

## 2. Objectives

❖ To furnish an overview of IoT

❖ To provide a comprehensive review on application of IoT in libraries

❖ To identify prospective areas where IoT can be applied effectively in libraries.

## 3. Methodology

The study used Google scholar to find articles published on IoT and its applications in libraries. The study covers articles and research papers published during 2010 to 2019.

## 4. Application of IoT in Libraries: Reviews

Fernandez (2015) put forward the concept of IoT and stated that the libraries have a role to play to implement the IoT in their own environments in ways that align with their values. Pujar and Satyanarayana (2015) projected the various applications of IoT in libraries viz energy management, virtual library card, smart digital shelves, real time data of patron's requests, IoT enabled mobile devices to locate favorite books etc. In an OCLC survey it was found that many librarians were familiar with IoT technologies (Hoy, 2015) and listed different methods of integrating IoT tools to library activities. These included inventory control, mobile reference, resource availability etc. Wójcik (2016) proposed a theoretical model of IoT usage in library services

after reviewing related literature of IoT implementation in libraries. Nag and Nikam (2016) proposed IoT technologies like cloud computing, magic mirror, pressure sensor pads through wireless sensor for better management of services in the academic libraries.

Ju and Shen (2015) proposed a novel solution called "Internet of Knowledge (IoK)", which can be used to organize scattered resources into a value-added knowledge asset for serving any specific objective through internet connection. Miorandi (2012) recommended that IoT-enabled technologies can be used to greatly enhance the performance of current solutions, providing cheaper and less invasive alternatives to the widespread deployment of cameras while at the same time preserving users' privacy. Makori (2017) noted the power of IoT in transforming and changing academic and research information organizations as the source of knowledge in addition to expanding access to education, data, information and communication anywhere anytime through hyper connectivity and networking. Kim *et al* (2017) analysed academia perception of IoT using the analysis of words frequency, co-occurrence, and distance.

Abuarqoub *et al* (2017**)** explored the possibility of IoT applications in smart buildings. Smart buildings use IoT-enabled real-time recording of environmental data to reduce the use of energy and to improve the user's comfort. Several foreign universities developed smart buildings providing better energy savings, monitoring and alarm systems. It confirmed that IoT applications can be effectively applied to enhance building management systems in libraries. Patel (2019) proposed an energy efficient system providing technical solution to conserve energy in library and

other buildings using two main sensors to detect human presence. The technology effectively controlled usage of electrical devices when not in use. Most of the studies showed that IoT can be effectively integrated into the physical space of the library. Hahn (2017) in "Library technology reports" described "Measure the Future project" which envisaged producing hardware and software solutions that can give a "Google-Analytics-style" dashboard for the library building. It will record the total number of footfalls, the browsing habits of users, and the sections of the library, which was frequented by the users. In this project sensors can collect data about the usage of library spaces. This in turn will direct librarians to make important decisions regarding usage pattern and help to provide efficient user services.

IoT can make great revolutions in library materials management. Renold and Rani (2013) proposed RFID based library management system. Li (2014) discussed IoT applications in university library management with the integration of RFID. Cheng *et al* (2016) discussed library management system with RFID and WiFi. Li *et al* (2016) designed IoT based library materials management system.

The IoT can also be used in digital library (DLs) and Integrated Library Systems applications. Fortino *et al* (2016) discussed inclusion of Smart Objects (SOs) into DLs and stressed that such an inclusion would enable, from one perspective, to effectively support discovery, querying and management of SOs through tools and facilities provided by modern DLs and, from another perspective, to extend currently available DLs with a new type of object to collect, manage and preserve. Noh (2015) proposed intelligence based digital libraries. Mohideen *et al* (2017) proposed an IoT reference mode for assessing

DLs. Stefanidis and Tsakonas (2015) reported the application in the SELIDA framework, which used KOHA ILS as the prototype.

Massis (2016) addressed the security and privacy concerns regarding IoT application in libraries. Libraries must have the proper infrastructure to coordinate all components necessary to link the systems and devices. Librarians must be aware that IoT can disrupt the library services and alert patrons about the risks involved when using their networks, their hardware and software. The users' smartphone, tablet, or laptop can be connected to the devices at libraries with risks involving of privacy issues. Kamalrudin *et al* (2018) also pointed out security concerns with IoT applications.

## 5. IoT Applications in Libraries

There are many potential areas identified by different researchers for the application of IoT in libraries. It can be used to track and trace library materials and promote self-check-outs. It can also be used for consulting and training, sharing of information, library marketing and promotion. The literature search shows the infinite possibilities of IoT application in libraries. Most prominent applications derived from the literature reviewed are listed below:

### 5.1 Smart Library Buildings

In IoT based library building concept sensors will be deployed into building so as to monitor the building operations. It can optimize the control of lighting, cooling and heating. It is also helpful for fire protection. Sun (2014) proposed that IoT based buildings provide a clean and comfortable learning environment for readers. The intelligent fire and security systems can ensure the safety of personnel and buildings (Nie, 2016). The automatically

adjusting temperature and lighting improve energy efficiency. IoT technology can be used for collecting data regarding the usage of printed and electronic resources, suitability of the building, the cleanliness of the restrooms and the movement of furniture in the most used areas of the library for study and research. It enables the users to know the current user denseness and accessibility of reader's cubicles, desktops and for printers. IoT enables librarians to know busy as well as less used space of the library. This will help the authorities to make strategic decisions regarding space management.

## 5.2 Personalized services

With the help of IoT, libraries can provide a number of personalized services. Wojcik (2016) explained that IoT can be used to deliver contextual hints and information about resources connected with current user interest. Mobile applications can be integrated with existing library systems. IoT would be able to communicate to a user about the commencement of new additions in his area of interest as well as related works. Users can receive notifications about their account status, about library events or search through catalogs.

## 5.3 Locating Books and other Materials

The misplacement of books is a burden for professionals. IoT book tracking facility is very helpful for searching books on the shelf and locating misplaced books. Brian, Arockiam & Malarchelvi (2014) proposed an IoT based Smart Library system, which provides the luxury of fetching a book from its place with the assistance of an IoT based interconnected system using a Wi-Fi based Local Positioning System (LPS) and Near Field Communication (NFC) tags. NFC enabled smart phone authenticates a user along with his biometric

fingerprint. LPS enables a user to trace a book and its exact location from OPAC and to get the information on his smart phone. NFC scanners located at the library doors are triggered if an unissued book is taken out. This system is helpful for the users and librarians to easily locate and issue books in large libraries.

## 5.4 Library orientation and Information Literacy

Library orientation programme ensures the familiarization of library resources, services and facilities to new members. IoT applications enhance the power of librarians in teaching users about library services using mobile applications, making virtual tours and exploring video contents. When users visit particular sections of a library, wireless devices recognize the users and play audio or video guiding the users on the various services in the library. IoT could be used for obtaining data on users by which library can customize several services.

## 5.5 Smart Circulation Control

IoT can give alert to users about their current holdings and overdue dates and fine details. Patrons can pay fine by online. Li *et al* (2016) designed an IoT system for library materials management using Android based UHF mobile reader. It can be installed with library application software at the entrance of IOT System for efficiently managing Library collections. It enables searching, self-help borrowing, returning and renewing library materials with Android mobile readers anytime and anywhere. Users are authenticated with an ID and password to log in to the system. The user interactive interface of the Android mobile reader helps the users to borrow/return books on their own.

**5.6 Inventory Control**

The Library resources can be controlled by applying sensors on them. IoT enabled libraries can easily trace the resources. Li et al (2016) reviewed that IoT enables searching and finding mis-shelved/ misplaced materials within no time. Using UHF RFID tags on library materials shelf, Android mobile readers read the tags' serial numbers, which are keys to the library database. A detailed list of materials available on the shelf is shown on the user interface of Android mobile reader. The misplaced books are highlighted and it will help reduce the amount of work involved in stock verification.

**6. Conclusion**

Innovation of IoT and associated technologies provide practical aspects of attaining sustainable information development practices in the contemporary knowledge society (Makori, 2017). The application of IoT is an emerging concept in library and information science. In application level, there are many challenges. Along with security and privacy, standardization is also a great dispute for the adoption of IoT in libraries. Libraries can take advantage of IoT technologies in the various library services. Librarians have to think and act together to implement the new technology for enhancing the services and facilities at their libraries and information centres.

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